# 3 Model Examination

Initially, numerical experiments were conducted to determine the optimum manner of simulation. Several runs were made of a hypothetical channel configuration to assess the effects of computational mesh refinement, boundary conditions, and vessel acceleration.

## Grid Considerations

Simulations were made to determine the grid density required to adequately resolve the flow field. Basically, the vessel geometry sets the resolution of the finite element mesh. Particular attention was paid to the mesh along the vessel path where the flow gradients are largest. Typically, the vessels modeled are tow configurations three barges wide (about a 32.0-m-wide hull).

Initially, grids were composed of two elements across the 32-m-wide vessel. These results, shown in Plate 1, were compared with those obtained for three elements across the vessel. This process was continued until additional resolution did not significantly change the solution. Plate 1 shows that the three- and four-element results are essentially the same.

Longitudinal resolution was found to be adequate when two elements were used to represent the length of each barge, 59.4 m. Thus a longitudinal-to-transverse aspect ratio of 3.7 was used for each element representing the sailing line. Time-step size was chosen so that the vessel moved one element longitudinally in each time-step.

## Boundary Conditions

The first experiments simulated cases with no ambient flow, so each of the four boundaries was treated as no-flux boundaries. Early results revealed that a wave was generated at the startup of the simulated tow. This "startup wave" traveled at the speed of a gravity wave, $c = (gh)^{1/2}$ , in front of and away from the vessel, because the wave speed was larger than the vessel speed. When the startup wave reached the opposite end of the domain, this no-flux boundary reflected the wave. The model runs were supposed to simulate a vessel that had been traveling for quite some time, so that the results would be free from startup noise. In order to reduce the presence of the reflected startup wave in the results, the boundary in the direction of the vessel travel was treated as an outflow boundary. A tailwater elevation equal to the initial water-surface elevation was applied as the boundary condition at the outflow boundary.

## Model Startup

The model allows the user to specify a linear acceleration from an initial vessel speed of zero to the steady vessel speed. Experiments were conducted to determine the sensitivity of results to the model startup rate. Model results using various simulated vessel accelerations were compared. These comparisons were of time-history plots of velocity and water-surface elevations at a point in the flow field.

Three runs were made to assess the impact that the initial acceleration of the vessel had on the equilibrium results. The acceleration time is defined as the time required for the vessel, starting at rest, to reach the final velocity of 10 fps (3.048 m/sec). All accelerations were specified as linear. The flow field solutions for acceleration times of 97.5 sec, 9.75 sec, and 195 sec were compared. Time-history graphs for each run indicate that an equilibrium state relative to the vessel was reached. The effects of vessel startup are best seen by comparing variables at a given spatial location for various acceleration times. Plate 2 is a time-history of the water-surface elevation and the longitudinal velocity at a particular point located at the top of the channel side slope. It is evident from these plots that the acceleration time (within the range evaluated) did not appreciably affect the equilibrium results. Each of the three numerical experiments produced essentially the same return current and drawdown.